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On extreme and exceptionals variation of DIATOMS, in some White Mountain localities, &c.

BY F. W. LEWIS, M. D.

In my notice of some new and singular intermediate forms of Diatomaceæ from the Saco headwaters, in the Proceedings of the Academy for December, 1863, I advanced a theory based on the comparative absence of *Synedra* and *Nitzschia* in the sub-peat of this country, that these curious species were *transitional* or *comprehensive types* conducting from *Surirella* and allied genera, towards the more modern *Synedra* and *Nitzschia*; and that their continuance as living organisms probably depended on exceptional conditions of soil and water, more or less limited in their influence, peculiar to the Saco and similar localities.

Since the publication of that paper I have received from my friend, Mr. C. Stodder, of Boston, a very interesting lot of slides containing all of these anomalous species, prepared by himself and Mr. R. C. Greenleaf, of Boston, from gatherings at various points along the White Mountain range.

His localities are as follows:

(1.) "Brook near the Flume," (Franconia Notch)—thirty miles from the Saco pond, and near the western outlet of the valley; contains *Surirella Baileyi*, *S. intermedia*, *Actinella punctata*, *Eunotia incisa*.

(2.) "Lafayette Mountain Lake," not many miles distant from the preceding. This lake is at a considerable elevation; a still sheet of water; contains *Surirella intermedia*, *Actinella punctata*, *Eunotia incisa*, *Synedra hemicyclus*.

(3.) "Brook near Bethlehem," on the S. E. side of the Crawford Notch (Saco) about 15 miles distant, also in the valley; contains *Surirella intermedia*, *S. anceps*, *S. delicatissima*, *S. Baileyi*, *Synedra hemicyclus*.

(4.) "Maurans Lake," on the Cannon Mountain, near Franconia; contains *Surirella Baileyi*, *S. anceps*, *S. delicatissima*, *Actinella punctata*, *Synedra hemicyclus*.

Of this locality Mr. S. writes, "This Lake is on the Cannon Mountain at a high level rarely visited by travellers. The gathering is surface water."

(5.) "Bemis Pond," not many miles from the Saco spring, is a small Lake. The gathering, according to Mr. S., is "a peculiar sub-aqueous deposit" forming the bottom of the pond, "about six feet thick, and composed of nearly pure diatoms." The contained species are *Surirella Baileyi*, *S. intermedia*, *S. anceps*, *Eunotia incisa*.

Mr. Stodder adds, "that in his opinion the only explanation of the origin of this and other similar deposits is afforded on the supposition that these diatoms were originally carried out into the still waters of the lake by small streams, and there deposited," an explanation not altogether satisfactory, as most of the species are still-water forms: *Navicula rhomboides*, *N. firma*, *N. major*, *Eunotia robusta*, &c., usually found in ponds and boggy pools.

Similar deposits, not containing any of the *transitional* species, occur at other localities in New England. One of the most remarkable, ten feet in thickness, is at Randolph, Massachusetts, another at Bristol, N. H.

Mr. S. thinks, also, that these beds have been deposited at varying periods since the *glacial* period.

(6.) "Echo Lake" (Franconia Notch,) a remarkably beautiful pond lying in the very gorge of the Notch; contains *Surirella intermedia*, *Synedra hemicyclus*, *Eunotia incisa*, and curious varieties of *Navicula sericans* and *Odontidium tabellaria*, hereafter to be noticed.

(7.) "Gibbs Falls," a short distance from the Saco springs to the west, contains *Surirella intermedia*, *S. delicatissima*, *Actinella punctata*, *Eunotia incisa*, along with recent species.

(8.) "Milldam at Gorham," on the Glen side of Mount Washington, collected 1865.]

tains *Surirella intermedia*, *S. anceps*, *S. delicatissima*, *Eunotia incisa*, &c., along with recent species.

These localities are all within the range of glacial influence.

After a careful examination of the slides, prepared from gatherings from these localities, I have been struck not only by a general correspondence in their species and varieties to those of the Saco and Wolfboro muds, but also by their unlikeness to species and varieties outside the White Mountain tract. In speaking of the Saco and Wolfboro species I alluded to their general resemblance to those of the *sub-peat* and *peat* deposits; the same remark of course holds good in reference to Mr. Stodder's localities. I will here simply confine myself to the statement of this general resemblance which further on will be illustrated by a table of species.

There is one point, however, relating to the curious tendency to variation, usually on a definite direction, apparent in many of these localities in common with post-tertiary deposits in other northern sections of this country, which requires a passing notice.

This tendency, which for convenience I shall call *metamorphic*, seems to coincide with the *abundant* introduction of certain genera in new localities. It is marked by a singular relaxation of the laws governing what I have before termed the *non-essential* characters of genus; in other words, while respecting the more fixed and positive generic characters (*essential*), as *alve*, *canaliculi*, *median lines*, *nodules*, &c., it would seem to exhaust its influence on the more *general* and *unimportant* ones, as size, outline, striation, &c., common to all diatoms (*non-essential*).

Besides the *intermediate* or *comprehensive* type already spoken of, there would appear to result from this *metamorphic* tendency a *subjective* variation in many co-existing genera whether allied or not to the incoming one. This variation, which is not always special in its direction towards any type or genus, affects principally the size, form, valvular outline and striation of many species, manifesting itself oftenest in a disposition to assume an *undulate*, *crenulate*, *apiculate* or even *cruciform* shape; more rarely to lose these characters. It would seem to originate in a superabundance of the sporangial element, and frequently begets irregular, abnormal or unsymmetrical forms, according to the more or less spasmodic or intermittent action of the disturbing force. I may add that, in accordance with a well known law, most of these so formed varieties, where involving alteration of *generic* characters, as *Surirella intermedia*, *S. anceps*, &c., or where irregular and unsymmetrical, as *Actinella*, either rapidly disappear by a process of degeneration (visible in *S. intermedia*), or revert to the normal type, while the extreme *varieties*, not implicating *generic* character, on the other hand may often become more or less permanent, as in *Navicula firma*, *N. rhomboïdes*, *N. serians*, and others.

To render more intelligible what I have tried to explain above, I shall now notice a few of the most remarkable varieties contained in the Saco spring, Wolfboro, and Mr. Stodder's localities.

(1.) "NAVICULA SERIANS" (Kutz.) "V. acute; *transverse* striæ faint, 60 in .100; *longitudinal* distinct, 36 in .100;" frustules often cohering: Length .0017" "to .0035" (Smith.)

(2.) Var. *a* (*apiculate*.) V. varying from lanceolate elliptic to rhomboid, with apices more or less produced and capitate (fig. 5a, pl. ii.)

(3.) Var. *b* (*cruciform*.) = *N. foliis*, (Ehr.) = *N. inflata*, (Ehr.)? "V. much inflated, compressed, sloping abruptly towards the produced and often truncate apices; extreme variety cruciform," (fig. 5b, pl. ii.)

Var. *a*. (*apiculate*) about two-thirds, and Var. *b*. (*cruciform*) less than one-half the length of the typical form.

*Striation* in both varieties beyond a certain distortion on the *latter* variety precisely resembling that of the typical form.

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My attention was attracted long since, by the singular likeness, in striation, median nodule, and general character, of *Navicula serians* to *N. follis*, (Ehr.), a form not uncommon in northern post glacial deposits.

Ehrenberg's loose figures of the latter (*N. follis*), give so many varieties of outline, and his description is so vague, that in time it seems to have become confounded by the English writers, with *Navicula inflata*, a species having no analogies to it beyond a slight resemblance in outline.

Indeed it is probable, that Ehrenberg himself, owing to the use of imperfect microscopes may have been led to associate these two very distinct species, and in distributing specimens may thus have originated the mistake.

However this may be, it is evident that in describing the form called *N. follis*, in the Bridgewater peat, (Mass.) he did mean the one figured as var. *b. (cruciform)*, of *N. serians*, fig. 5 *b.* pl. ii.\*

The general resemblance in character, however, would not have sufficed to prove the specific identity of these two forms, viz. *N. serians* and its var. *b. cruciform*,—had it not been for the discovery of a second variety which bridges over the interspace—that figured as *N. serians*, var. *a.* fig. 5, *a.* pl. ii. This variety occurs in two of the White Mountain localities, Bemis Lake, and Echo Lake, along with the typical form and the cruciform, var. *b.*, a strong corroborative evidence beside that afforded by numerous intermediate varieties of a common derivation.

As this is a fact which, if recognized, involves a most important point in its bearing on the laws which determine species, I have drawn with utmost care (fig. 5, *a.* *b.* pl. ii.) the valves of what appear to be average specimens of these two varieties. The Bemis Lake slides of Mr. Samuels, now very difficult to obtain, are very carefully mounted, and afford beautiful illustrations of these forms,—as well as of *Stauroneis Stodderii*, n. sp. (Greenleaf,) (fig. 6, pl. ii.) The material is quite scarce at the present time, although it could no doubt readily be procured from the original locality.

(1). "NAVICULA FIRMA" (Kutz).—Large, turgid, oblong, lanceolate, with obtuse, cuneate ends, thick borders, and large median nodule; striæ wanting, or obscure."

(2). "Varieties."—(α). *linear oblong*, (*Navicula iridis*.) β. *pointed elliptic*, (*N. dilatata*). γ. *cuneate* (*N. amphigomphus*.)

(3). "Secondary or metamorphic varieties." δ. *triundulate*, (not the same as *N. Hitchcockii*). ε. *produced* (*N. producta*, *N. affinis*). ζ. *apiculate*. (*N. amphirynchus*.)

The specific identity of *N. iridis*, *N. dilatata*, *N. amphigomphus*, and perhaps one or two other reputed species has, I believe, been generally suspected, if not recognized. Certainly, it would be difficult for any one carefully studying the Northern deposits of this country, whether recent or fossil, to resist the conviction, that they really have a common origin. With regard, however, to some of those I have termed *secondary* or *metamorphic*, their common derivation from *N. firma* is not so obvious. I believe them, notwithstanding, to be all varieties of that species, a conclusion I have arrived at, after a careful comparison of gatherings from numerous localities. As, however, a conclusion so formed may be regarded as more a matter of prepossession than admitting of proof, I shall not undertake to illustrate it by elaborate descriptions of these varieties; but this much may be said, that what has hitherto kept apart many of the best known of them, is simply difference in valvular *outline* and *number of striæ*. If, hereafter, my view with regard to the unimportance and mutability of these characters be proved correct, the union of some, if not all these reputed species will probably be necessary.

Taking all the enumerated varieties, there appear to be certain general

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(\*I am the more certain of this, from my friend Prof. H. L. Smith, of Kenyon College, O., having recently written to me, calling attention to this very fact.)

points of resemblance between them. These are—(1). "*The large open median nodular space.*"

(2). "*The intra-marginal, dark, and more or less broken line or lines, with separation and distortion on the peculiar wavy longitudinal striation at that point.*"

(3). "*The sharp, clear, parallel, transverse striae.*"

This last character seems to me, to afford a valuable clue for determining the *primary* or *secondary* nature of any *undulate* or *apiculate* form. As a general rule, it will be found, I think, that *parallel transverse striae*, coinciding with an *undulate margin*, imply a *secondary* or *metamorphic* action on a species whose original outline was *smooth*; while on the other hand, a *radiant transverse striation*, or, rather, one constantly *perpendicular* to the *marginal line*, indicates that an *undulate* outline is *primary*. Thus, *e. g.* the *triundulate* outline of *Navicula Hitchcockii*, concurring with a *parallel, transverse, striation*, is most likely, *secondary*; also the crenulate dorsum of *Himantidium undulatum* (extreme variety). While the large and showy *Navicula Sillimanorum*, (fig. 8, pl. ii.) ought by the same rule to possess a *primary* outline, although much exaggerated and intensified. In the *apiculate* forms, the *metamorphic* force being operative over but a small terminal portion of the valvular margin, renders the rule less valuable.

Although liable to many exceptions, this rule may be sufficiently general to possess a practical value, when taken in connection with other means of proof.

I cannot leave these varieties of *N. firma*, without adverting to the species known as *N. Hitchcockii*, which has been regarded by some, as a variety of the former species. There is a *triundulate* variety of *N. firma* approaching very near to it in size and outline, but differing essentially in the median line, which in *N. Hitchcockii* is remarkable as having on either side a double line, nearly parallel to its course throughout. That it is of the habit of *N. firma*, however, can hardly be questioned; and although not clearly traceable to that species, may it not, perhaps, be a compound variety, resulting from the conjugation of species reputed distinct, but in reality, only so sporangially?

I take occasion here to quote some very interesting remarks of Professor H. L. Smith, who has long been studying the habits of *living diatomaceae*, and whose observations bearing on this and other points in that connection, will, I trust, shortly be made public. In a recent letter to me, speaking on this very subject of extreme variation, he says: "*The variety of N. firma? like N. Hitchcockii, somewhat, on one of the slides you recently sent me (Saco River,) is curious; but if you will examine the Bridgewater deposit, I think you will see something about N. foliis of Ehr., that makes one almost say it is only a variety of N. seriens. The departure is greater, even as to form alone, than that of the specimen of N. firma? like Hitchcockii is from the type of that species.*"—He adds: "*when I find N. amphirhynchus conjugating and producing N. firma, Stauroneis gracilis producing St. phenicenteron, and Surirella splendida, S. nobilis, quite different in form and striation, I cannot but doubt the propriety of making a new species out of every different shape and marking.*"

The views of Prof. Smith here expressed, cannot fail to awaken a lively interest in all who desire to have light thrown upon this perplexing question, and it is earnestly to be hoped, that the matured result of his investigations will not long be delayed.

NAVICULA RHOMBOIDES is, with one or two exceptions, of all northern species the most common and widely distributed. It offers a broad range of form and outline. Like *N. firma*, it has its *elliptic*, *produced* and *apiculate* forms. I may preface what I have to say of this species, by remarking that it is, in my opinion, impossible to determine on any positive characters, which shall distinguish it from *N. crassinervia*. The small apiculate variety which I have

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been accustomed to regard as that species, clearly runs into the typical *N. rhomboides*, of which it is most probably a colletonemoid (sporangial) offset.

Two of the numerous varieties of this species, seem to be permanently distinct—more so, in fact, than in most permanent varieties—although connected by intermediate forms with the ordinary type.

*N. rhomboides*, (Ehr.) V. nearly quadrangular, striæ, faint, parallel 85 in. .001". Length .0022", to .0037". (Smith).

*Sporangial Varieties*, (1). (a). "Frustule large, V. rhomboid to lanceolate—median line double, presenting at the terminal nodules a peculiar arrangement, somewhat similar to the "porte crayon" of Dr. Greville, as it exists in *N. Lewisiana*—only much less obvious." (pl. ii., fig. 11).

The *transverse* striæ in this form, are about, 60 in .001", "the *longitudinal*, about, 45 in .001". Length variable.

*Hab.*—In nearly all fossil and recent northern deposits.

(2). (b). *N. diaphana?* (Ehr.) V. lanceolate—extremities slightly produced—obtuse, median line thicker than in var. *a*, terminating in obtuse, rounded, nodular expansions rarely attenuated laterally—striæ *transverse*, about 50 a 55 in .001". *Longitudinal*, coarser and more wavy than in var. *a*, more or less indistinct for some distance round the central nodule.

*Hab.*—Bemis Lake, abundant, Saco pond, Wolfboro, and other New England deposits. It is not so common as var. *a*. (pl. ii., fig. 10).

The former of these, is probably the ordinary sporangial variety of *N. rhomboides*; the latter, I have found more rarely in gatherings along the Saco Valley, and—I think, elsewhere in New England—I have been struck with the rarity of both these varieties, particularly, of var. *b*. on foreign slides.\*

Var. *a*, sometimes approaches var. *b* in outline; but, I have never seen the latter of a quadrangular or rhomboid shape. Occasionally the terminal nodule undergoes a trifling modification, becoming slightly indented at the rounded corners. This may, perhaps, be a compound variety.

Figured at pl. ii., fig. 21, is what I believe to be *N. Carassius*, (Ehr.), (*N. cocconeiformis*, (Smith)). (Gregory's new British sp. Mic. Jour. vol. iv. pl. i., fig. 22). This is a rare American species, usually fossil. The striæ are very hard to resolve. Some of the varieties of this diatom, suggest an affinity to *N. rhomboides*; but not sufficiently marked to warrant notice.

"*NAVICULA SILLIMANORUM*," (Ehr.) An exaggerated variety of this species, I have figured, (pl. ii., fig. 8). I have found it only in the Wolfboro mud. The typical form of Ehrenberg, occurs in some of the N. Hampshire deposits. It is a singularly compact and beautiful diatom—more nearly allied to *N. nobilis*, than to *N. tabellaria*—as is shown by the relations of the striæ to the marginal line, which according to the rule before mentioned, indicate the intensification of a *primary* undulate outline.

*NAVICULA GASTRUM*, (Ehr.)? fig. 17, pl. ii). Rare in the Wolfboro mud. I have not come across it elsewhere. The striation is more or less irregularly punctate around the median nodule, and along the median line, as in *N. granulata*. (Bailey). The striæ are radiant—otherwise, it might be set down as a degenerate variety of *N. firma*.

"*NAVICULA PLACENTA*," Ehr. fig. 4, pl. ii.—*N. apiculata*, Greg. (Mic. Jour., vol. iv., pl. i., fig. 13)—*N. rostellum*. (Smith). This little species is ventricose or elliptic, with a nipple-like projection, at each apex. It corresponds perfectly in outline, with Dr. Gregory's figure; but the striation is so peculiar in its arrangement, that I have thought it best to figure the valve. The striæ are of two kinds. (1). *transverse*, sharp, radiant, close. (2). *obliquely curved*

(\* The slides coming from abroad, labelled "Amician test," are, I believe, prepared from material obtained from this country.)

in both directions towards the median line, crossing as in *Hyalodiscus subtilis*. (Bailey).—coarser than the *transverse*. These characters are constant in all the specimens I have of this species, from this and other localities.—Wolfboro, N. H., Duck creek, Del. river.

**STAURONEIS.** This genus is very abundantly represented, particularly in the Wolfboro mud. It is common in all post tertiary deposits, and presents a bewildering looseness of character.

I have long tried to understand the meaning of *S. Baileyi*? (Ehr.) and its varieties. Some time ago, I came to the conclusion, that the one having the quadrangular shape and terminal inflexion of *St. acuta* was a sporangial var. of that species; and that the other (Pteroidea) bore the same relation to *St. phenicenteron*. This belief has recently been shaken, by my finding the latter variety (Pteroidea) in the "Nova Scotia" deposit, with a very strongly marked terminal inflexion, and the other characters of size, striation, and outline, so variable as to compel the conclusion, that they are both *interchangeable* varieties of a common species—possibly *St. phenicenteron*.

A very interesting study of these forms is afforded, by the Nova Scotia, Blue Hill pond, (Me.) and, in fact, by nearly all the northern deposits, recent and fossil.

**STAURONEIS LEGUMEN**, (Ehr.) The aberrant variety, (pl. ii., fig. 14), will show the range of outline in this species. Frustules of this shape occur sparingly in the Wolfboro mud, along with the ordinary form.

**STAURONEIS AMPHICEPHALA**, (Kutz.) This species I notice, to direct attention to the figure of *S. anceps* in Prof. Smith's "Synopsis," which, in all respects, answers to the description and figure of Kützing's (Bacillarien, p. 105, pl. 30, fig. 25). *S. amphicephala*. *S. anceps*, (Ehr.), is subcapitate with truncate apices, *S. amphicephala*, capitate with rounded ends. Very likely, these two species are identical. The mere length or relations of the stauros to the margin not constituting a valid reason for keeping them apart.

I cannot close what I have to say about *Stauroneis* and its varieties, without alluding to a *stauroneiform* tendency which seems to prevail in certain localities. This is marked in the Wolfboro, where seven species of *Stauroneis* co-exist with a number of *stauroneiform* varieties of Navicula.

I now pass on to notice some varieties of—

**HIMANTIDIUM and EUNOTIA.** I have before spoken of the prevalence of these genera in the Saco and cotemporary deposits, and likewise of the remarkable subordination of their specific character to the *metamorphic* force, as exemplified in *Himantidium pectinale*, and *H. arcus*, *Eunotia robusta* and *E. incisa*. I now give a few illustrations of the most common of these metamorphic varieties, (pl. ii., fig. 12, 13, etc.) which strongly corroborate the view entertained by the late Prof. W. Smith, of the probable common derivation of many of the known British species of *Himantidium*, from two types; viz.: *H. pectinale* and *H. arcus*. (vide Synopsis, vol. ii., p. 11).

Of these varieties, pl. ii., fig. 13a, represents a common sporangial form of *Himantidium undulatum*. It will be seen that the *dorsum* is already hollowed out as a preliminary step towards another common variety (sporangial) of the same diatom\* of which variety I have figured only the extreme and last

stage, at pl. ii., fig. b. This last, represents quite nearly *two* conjoined frustules of *H. undulatum* (type), as does the intermediate variety, *two* of *H. pectinale*.

Whether or no these remarkable sporangial frustules ever undergo trans-

\* (Those slides prepared by Mr. Samuels, of Boston, labelled *Himantidium undulatum*, afford a very fine illustration of this variety, which is abundant in fresh water streams throughout Massachusetts.)

verse division, I am unable to say from actual observation; but their appearance is certainly suggestive of that phenomenon. I ought to add, that the *secondary* gibbositities on the ventral aspect of var. *b.*, are rarely as well marked as shown in the figure (13 *b.* pl. ii).

Of *EUNOTIA INCISA*, pl. ii., fig. 12*a.*, represents an extreme variety. The extraordinary attenuation of the valve well illustrates the *synedroid* bias, noticeable in the Saco, and, to a lesser degree, in the Wolfboro muds.

The inflexion peculiar to the terminal portion of the valve in these bacillar varieties of *E. incisa*, often nearly reaches the dorsum. On the other hand, an opposite variety of *E. incisa* occurs, which is nearly as broad as long.\*

*Eunotia camelus*? (fig. 12*b.* pl. ii.) is probably allied to *E. incisa*. Some of the frustules are long and narrow, with hardly any perceptible undulation. = *Eu. impressa*, (Ehr.), occurs sparsely at Wolfboro and Bemis Lake.

*EUNOTIA BACTRIANA*, (Ehr.), (fig. 16, pl. ii.) is quite common. There appears to be considerable range of variation in this species.

*EUNOTIA PENTAGLYPHIS*, (Ehr.), as figured (fig. 4, pl. ii.) is also a changeable form. It is widely distributed in the post-tertiary deposits, and has all the characters of a *metamorphic* variety of *Eu. robusta*.

*ODONTIDIUM TABELLARIA*, (Smith) = *Dimeregramma tabellaria*, (Ralfs.) I have retained this name, as that by which this diatom is best known. The two varieties figured in Smith's British Diatomaceæ, and which may, for convenience, be termed *primary* and *secondary*, seem to be peculiarly obnoxious to the *metamorphic* force. Figs. 1 and 2, pl. ii., represent a series of elongated varieties from the Saco river, (Synedroid). Of these, two are specially noticeable, 2*b.* and 2*d.* The first of these has strong marginal puncta; (Nitzschoid?) while the second exemplifies the same suggestive principle of symmetrical variation seen in *Himantidium undulatum*, fig. 13, var. *b.* pl. ii.

The *punctate* tendency, which is quite exceptional, manifesting itself only on a few frustules, is to a lesser degree observable in *Tabellaria*, in the same deposit.

There remain to be considered, one or two forms in these deposits, which are not clearly traceable to any known species.

(1). *NAVICULA (STAURONEIFORM)* n. sp.? (pl. ii. fig. 9). F. V. not ascertained. V. lanceolate, gradually attenuated towards the capitate or sub-capitate extremities. Striæ sub-marginal, interrupted for a considerable space opposite the central nodule.

*Hab.*—Wolfboro. Common. (Fig. 9, pl. ii.)

This little form I have not named, as it may possibly prove a stauroneiform variety of some known species. This *stauroneiform* habit is very obvious in the Wolfboro varieties; as is the *synedroid*, in the Saco.

(2). *STAURONEIS STODDERII*, n. sp. (Greenleaf), pl. ii. fig. 6.) F. V. Linear, with slightly rounded ends; connecting membrane slight and fragile. V. elliptic lanceolate, with more or less produced and slender extremities. *Stauros* linear, reaching the margin. Striæ (longitudinal) parallel, sharp and clear. Variable in number. Striæ (transverse), radiant, distinct, about 55 in .001. Length variable.

*Hab.* of *St. phenicenteron* and *St. amphicephala*. Bemis Lake, Wolfboro, Gorham pond.

This beautiful species was first made known to me by Mr. Stodder, who had it from Mr. R. C. Greenleaf, of Boston, who names it *St. Stodderii*, in compliment to the former observer. He has permitted me to describe it.

\*(*Eunotia nodosa*. Var. *Himantidium pectinale*? in the Bemis Lake, presents a remarkable variety, analogous to the above in proportions. It is also nearly as broad as long, and slightly constricted.)



The valves which are singularly light and graceful, the linear striation giving the surface much the aspect of a scale of *Lepisma*, are rarely found united by the connecting membrane. Mr. Greenleaf communicates the following facts, with relation to this diatom; "The *longitudinal* lines are parallel throughout, gradually fading away, so that they are not seen near the apices; they are faintly visible with careful illumination and focussing over the stauros; margin beaded." I have not been able to verify Mr. G.'s observations. It seems to me, that the *longitudinal* striæ are *internal*, and underlie the stauros, and that they are traceable up to the apex, in that limited number of parallel striæ which the narrow area of the extremity can accommodate. The beaded marginal appearance, is probably due to the effect produced by the inflexion of the striæ. Mr. Stodder believes the longitudinal striæ to be corrugations of the internal membrane, designed to strengthen the valve.

The figure (fig. 6, pl. ii.) is not sufficiently elongate for an average specimen of this species.

"TETRACYCLUS" (abnormal)? (pl. ii., fig. 3a, & b.) F. V., much as in the typical form, (genus); filament with a central constriction; frustules small; septa alternate, equal; V. deeply constricted in the centre, (not unlike a dumb-bell crystal of oxalate of lime).

*Hab.* of *Tabellaria* and *Tetracyclus*. Lafayette Mt. Lake.

This singular form occurs only at the above locality. Being minute and much intermixed with *Tabellaria* and *Odontidium tabellaria*, it is apt to be overlooked on a crowded slide. The septa are quite insignificant. They exist at both ends of the valve. This anomalous form suggests a *metamorphic* variation, mediate between *Tabellaria* and *Tetracyclus*, and is a true *comprehensive type*, although less perfect than *Surirella intermedia*. The relations of the septa, small as they are to the valve, and to each other, are constantly those of *Tetracyclus*, (never of *Tabellaria*), though the impressible character of outline, passively yielding to the disturbing force, has wandered far away from the typical pattern of that genus.\*

I will now, as briefly as possible, sum up the conclusions I have tried to establish in this and the previous paper. After which summary will be found a comparative table of some of these species.

These are—(1). That the genera *Synedra*, *Nitzschia*, *Tabellaria*, and perhaps, *Odontidium* and *Himantidium*, made their first appearance as *prevalent* forms on this continent, at varying epochs, since the *Glacial* period.

(2). That there are epochs, which may be termed *transitory*, coinciding with the *abundant* introduction of genera, (as above), marked by a singular relaxation of the laws which govern generic character, (*metamorphic* force.)

(3). This *metamorphic* force while respecting the more fixed and positive generic characters, (*essential*), usually attacks the more variable and unimportant characters, (i. e. those common to most diatoms), (*non-essential*), of those genera most nearly allied to the *incoming* one, giving rise to *comprehensive* or *synthetic* forms; as *Surirella intermedia*, *Sanceps* &c.

(4). During these epochs, there would also seem to exist a *subjective* variation in many of the cotemporary genera, whether allied or not to the prevailing one—originating in this *objective* force—still affecting the *non-essential* characters, principally *form* and *outline*, e. g. *objective* genera *Synedra*,

\* (The *metamorphic* force seems to run riot in this particular locality, (Mt. Lafayette Lake), and nearly all the species appear to participate in this tendency to depart from their normal type. The largest and showiest frustules of the *pointed elliptic*, which is by far the finest variety of *N. firma*, pass down through many intermediate forms into a minute and characterless *N. affinis*, *N. rhomboides* ranges from the smallest *apiculate*, up to the magnificent var. b. (pl. ii., fig. 11), curious and anomalous varieties of *Tabellaria*, of *Odontidium tabellaria*, some punctate, others *Synedroid*, eccentric varieties of *Synedra hemicyclus*, of *Eumotia incisa*, *Eu. camelus*, *Eu. pentaglyphis*, *Eu. robusta*, of *Himantidium gracile*, concurring with the abnormal *Actinella punctata*, *Surirella intermedia*, and *S. delicatissima*, altogether form a grouping confused and incoherent beyond precedent.)

*Nitzschia*; subjective genera, *Surirella*, *Himantidium*, *Odontidium*, *Tabellaria*, *Eunotia*, and resultant varieties. (Pl. ii., figs. 1, 2, 12, 13).

(5). An extreme variation, *not special* in its direction towards any type or genus, extending to the valvular outline of many altogether distinct genera, characterizes these metamorphic epochs; manifesting itself in disposition to assume an *undulate*, *apiculate* or *crenulate* contour, or to lose these characters, e. g. *Eunotia incisa*, *Himantidium*, *Navicula serians*, *N. firma*; or in irregular, abnormal or unsymmetrical forms, due probably, to unequal or spasmodic action of the metamorphic force, e. g. *Actinella*, *Tetracyclus*, (fig. 3, pl. ii.)

(6). These so-formed varieties, where based upon changes of *generic* character, or where *abnormal* or *unsymmetrical*, are always short-lived; on the other hand, varieties *not* involving *generic* character, often become fixed and permanent, as *Navicula firma*, (var. *iridis*, *amphigomphus*, &c.) *N. serians*, var.  $\beta$ , *N. rhomboides*.

(7). That it is not improbable, that many species not reputed distinct, are capable of conjugating with each other; and that peculiarities of outline and striation constitute but uncertain data for division of species.

*Table of Species.*

(\*) Indicates the presence of species at the locality.

Localities where the "intermediate type" species occur.	Saco.	Wolfboro.	Lafayette Mt.	Bemis Lake.	Flume.	Bethlehem.	Mauran Lake.	Echo Lake.	Gibbs' Falls.	Gorham.
<i>Surirella Baileyi</i> .....	*	*	*	*	*	*	*	*	*	*
" <i>intermedia</i> .....	*	*	*	*	*	*	*	*	*	*
" <i>anceps</i> .....	*	*	*	*	*	*	*	*	*	*
" <i>delicatissima</i> .....	*	*	*	*	*	*	*	*	*	*
<i>Actinella punctata</i> .....	*	*	*	*	*	*	*	*	*	*

2.

Localities of species usually fossil, and of those metamorphic in the direction of <i>Synedra</i> , and <i>Nitzschia</i> .....	Bridgewater.	Blue Hill pond.	Saco.	Wolfboro.	Lafayette Mt.	Bemis Lake.	Flume.	Bethlehem.	Mauran Lake.	Echo Lake.	Gibbs' Falls.	Gorham.	Some of these species also illustrate the irregular variation of the next section, (No. 3). <i>Eunotia nodosa</i> , I have not noted, as it is but a doubtful species.
<i>Himantidium pectinale</i> .....	*	*	*	*	*	*	*	*	*	*	*	*	
" <i>arcus</i> .....	*	*	*	*	*	*	*	*	*	*	*	*	
<i>Eunotia incisa</i> (long var.) ...	?	?	*	*	*	*	*	*	*	*	*	*	
" <i>robusta</i> .....	*	*	*	*	*	*	*	*	*	*	?	?	
<i>Odontidium tabellaria</i> .....	*	?	*	*	*	*	*	*	*	*	*	*	
<i>Synedra hemicyclus</i> .....	?	?	*	?	*	*	*	*	*	*	*	*	

Species illustrating irregular variation not in any special direction.	Bridgewater.	Blue Hill pond.	Saco.	Wolboro.	Lafayette Mt.	Bemis Lake.	Flume.	Bethlehem.	Mauran Lake.	Echo Lake.	Gibbs' Falls.	Gorham.
<i>Navicula serians</i> .....	*	*	*	*	*	*	*	*	*	*	*	*
“ “ var. <i>a</i> .....	*	*	*	*	*	*	*	*	*	*	*	*
“ “ var. <i>b</i> .....	?	*	*	*	*	*	*	*	*	*	*	*
“ <i>firma</i> and var.....	*	*	*	*	*	*	*	*	*	*	*	*
“ <i>rhomboides</i> .....	*	*	*	*	*	*	*	*	*	*	*	*
“ “ var. <i>a</i> .....	?	*	*	*	*	*	*	*	*	*	*	*
“ “ var. <i>b</i> .....	?	*	*	*	*	*	*	*	*	*	*	*
<i>Stauroneis Baileyi</i> and var.....	*	*	*	*	*	*	*	*	*	*	*	*
<i>Eunotia incisa</i> , (ordinary var.).....	?	*	*	?	*	*	*	*	*	*	*	*
“ <i>pentaglyphis</i> .....	?	*	*	*	*	*	*	*	*	*	*	*
“ <i>bactriana</i> .....	?	*	*	*	*	*	*	*	*	*	*	*
<i>Tetracyclus</i> ? (abnormal).....	*	*	*	*	*	*	*	*	*	*	*	*
<i>Navicula Sillimanorum</i> .....	*	*	*	*	*	*	*	*	*	*	*	*
* <i>Surirella decora</i> .....	*	*	*	*	*	*	*	*	*	*	*	*

I add a list of the ordinary grouping of species in these localities. This is necessarily incomplete and liable to error, owing to the fact that in some of these muds, within the immediate influence of mountain streams, as parts of the Saco spring—the Flume—Bethel—there is a large dilution with more modern forms. These I have excluded and placed in a list by themselves. The absence of these species in the *still pond* localities of the White Mountains, is, I think, sufficient evidence of their *extraneous* habitat, when found along with the grouping below.

*Cymbella cuspidata*, *C. helvetica*, *Epithemia ventricosa*, *E. argus*, *Eunotia robusta*, *Eu. incisa*, *Surirella nobilis*, *S. oblonga*, *S. decora*, *Navicula firma*, *N. serians*, *N. rhomboides*, *N. major*, *N. tabellaria*, *N. viridis*, *N. acrospheria*, *N. radiosa*, *N. mesolepta*, *N. borealis*, *N. Staureiformis*, *N. elliptica*, *N. cuspidata*, *Stauroneis phenicenteron*, *St. gracilis*, *St. Baileyi*, *St. anceps*, *St. legumen*, *Cocconeis lanceolatum*, *C. cymbiforme*, *Gomphonema coronatum*, *G. turgidum*, (var. *G. capitatum*)? *Gomphonema*, (var. *G. acuminatum*), *Himantidium arcus*, *H. pectinale*, *Odontidium tabellaria*, *Fragillaria*, (doubtful?)—*Achnanthidium*? *Tetracyclus lacustris*, (rare). *Diatoma elongatum*, (rare), *Tabellaria vulgaris* and vars. *Orthosira orichalcea*, *Cocconeis Thwaitesii*, (rare), *Nitzschia spectabilis*, (rare), *Synedra ulna*, (rare), *Navicula*=*Amphiprora navicularis*, (Ehr.)? (common in sub-peat and peat), *Navicula scutelloides*, (rare).

The following are, probably, *extraneous* species:—*Odontidium mesodon*, *O. mutabile*, *Meridion circulare*, *Cocconeis placentula*, *Synedra radians*, *Nitzschia amphiozys*, *N. tenuis*, *Pleurosigma Spencerii*, *Gomphonema capitatum*, *G. geminatum*, *Asterionella formosa*, *Colletonema vulgare*.

*Denticula* and *Amphiprora* are not represented in any of these deposits, unless by one or two doubtful forms, one of which is figured in (pl. i., fig. 6), *Amp. ornata*, the only fresh water species, is not common so far north.

\*I have omitted to notice an abnormal variety of *Surirella decora*? in the Wolboro mud. This is ovate; the median line extending for little more than one half the length of the valve, leaving an equal open area at either end. From the extremities of the median line, the faint costæ branch out with a beautifully radiant arrangement, appearing as if they all arose from the same point. I have found this form also at Montmorency Falls, Canada.)

[Jan.

I had intended, in the present communication, to give a résumé of species contained in the "blue clay" of the Delaware river alluvium, and in adjacent localities along the river. This last I shall be obliged to defer; but as several of the figures published in my last paper were designed to illustrate it, I will briefly describe them.

"*AMPHORA INTERMEDIA*," n. sp.? (pl. i., 7 a, b and c). F. V. linear elliptic, or elliptic; margin of the inflected portion of the valve recurved, resembling a small ala; marginal pnncta distinct, V. arcuate, with rounded apices finely striated.

*Hab.*—Atlantic, N. J., rare.

This delicate and beautiful species, belongs to the complex *Amphoræ* of Dr. Gregory. Its outline and appearance on the F. V. are suggestive of *Amphiprora*, from which genus, however, the absence of the terminal nodules and its valvular outline remove it. The few specimens I have found, do not enable me to judge accurately as to its average length or striation.

*NAVICULA*—n. sp.? (pl. i., fig. 8) V. rhomboid, with cuneate slightly produced extremities, striæ radiant, moniliform.

The only specimen I have of this diatom, is a detached valve, from which the figure (pl. i., fig. 8), is taken.

*Hab.*—Blue clay, Kaighn's point, Del. river.

*AMPHIPRORA PULCHRA*, var.  $\beta$ . *A. conspicua* (Greville)? (pl. i., fig. 10, a and b). I am not sure, whether this fine diatom is identical with that figured in the Mic. Journal as *A. conspicua*. (Trans. Mic. Soc., vol. ix., pl. 10, fig. 16).

My figure, which is carefully drawn from a slide of Rockaway mud, differs certainly from that of the Mic. Journal. The frustules are always twisted, as shown in fig. 10a, pl. i., and the elongated nodules have much the look of canaliculi. Its habit is that of *A. pulchra*, of which species I have thought it a variety. It rarely attains half the size of that species; occurs sparingly in many brackish and marine localities.

*MASTOGLOIA ELEGANS*, n. sp. (pl. i., fig. 9). F. V. as shown at pl. ii., fig. 16. V. large, lanceolate, elliptic; extremities sometimes a little produced; *loculi* numerous; very minute; marginal; striæ sharp, clear, parallel; about 36 a 40 in .001". Median nodule laterally produced into a fine point. Habit and growth of *M. apiculata*, of which species it may be a permanent variety. I have not, however, been able to trace the connection.

It occurs along with *M. angulata*, and the above, at Atlantic, N. J., Cape May, (Schellinger's Inlet), and as a pure gathering; abundant.

*MASTOGLOIA KINSMANII*, n. sp. (pl. ii., fig. 15 a and b.) F. V. as shown at fig. 18b. V. lanceolate or elliptic, with more or less produced ends; *loculi* less numerous than in *M. apiculata* or *M. elegans*; the central 4 or 5, larger than the others; (this is a constant character).

Median line with a narrow blank space on either side, connivent at the apices; striæ sharp, radiant, about 40 in .001. Habit and growth of the preceding.

*Hab.*—Cape May, Cold spring, Atlantic marshes.

Not an uncommon species at the above localities. The frustule is quite thick, and of a dark, chocolate, brown color, when dry. This somewhat doubtful species I have named (provisionally) after my friend Mr. Kinsman, of this city, who first directed my attention to it, and to whom I am under great obligations for aid in mounting and preserving specimens, and for many valuable hints in their study.

There remain to be noticed, two very similar *Naviculæ*, having strong affinities with *N. Lewisiana*, (Grev.) One of them (pl. ii., fig. 19.) frequently occurs along with it, and is probably, an early stage of that diatom; and the 1865.]

other, (pl. ii., fig. 20,) is a not uncommon coastal species. Both are brackish. For convenience of reference, I have provisionally named these forms, whose claims to rank as distinct species are very questionable:

(1.) *NAVICULA INCOMPERTA*, (pl. ii., fig. 20.)—V. lanceolate elliptic, with a thick double median line; terminal nodules inconspicuous; *transverse striæ* parallel; about 70 in  $\cdot 001''$ ; *longitudinal striæ* wavy, faint, about 55 to 60, in  $\cdot 001$ . Cape May, Atlantic, and Rockaway Salt marshes, common.

(2.) *NAVICULA INTERPOSITA*, (pl. ii., fig. 19.)—V. elliptic, elongated, shorter than in the preceding; terminal nodules usually inconspicuous. *Transverse striæ* sharp, parallel, about 50 a 55 in  $\cdot 001''$ . *Longitudinal*, straight, parallel, about 45 a 50 in  $\cdot 001$ . Paraiba Harbor, S. A.; Wilmington R., Savannah, Ga.—C. Febiger.

The front view of both these species is linear, or sometimes slightly constricted, with abruptly rounded ends, to which the suddenly inflected terminal nodule gives an emarginate appearance, as is sometimes seen in *N. rhomboides*.

In *N. Lewisiana*, on the other hand, the front view is commonly a little inflated, and the terminal curves much more gradual. The straight and long terminal nodule of this last species, subtends the arc formed by this curve, whence, probably, arises a good deal of that apparent inflation of the "*extra median*" lines, spoken of by Dr. Greville. (Trans. Mic. Soc., vol. xi. N. S. p. 16.)

The variation in size, form and number of *striæ* is very considerable in all of these species from different localities, and for the reason this measures I have given above are only approximate.

As opportunity offers, I hope to continue the notice of the Delaware river, and adjacent coastal diatoms.

#### PLATE II.

Fig. (1.) *Odontidium tabellaria*.—Sporangial varieties of *primary* form. (*a*), ordinary form,  *$\beta$*  and  *$\gamma$* , elongated frustules.

(2.) *Odontidium tabellaria*.—Sporangial varieties of *secondary* form. (*b*), punctate variety of, *c*, elongated form, *d*, double sporangial frustule.

(3.) *Tetracyclus?* (abnormal)—*a*. V. *b*. F. V.

(4.) *Eunotia pentaglyphis*, (Ehr.)

(5.) *Navicula serians*, *a*, (*apiculate*), *b*, (*cruciform*) variety=*N. follis*.

(6.) *Stauroneis Stodderii*, n. sp. (Greenleaf).

(7.) *Navicula placenta*, Ehr.

(8.) *Navicula Sillimanorum*, Ehr.

(9.) *Navicula* (*Stauroneiform*), n. sp.?

(10.) *Navicula rhomboides*. Sporangial var. *b*.

(11.) *Navicula rhomboides*. Sporangial var. *a*.

(12.) *Eunotia incisa*. (*a*) extreme variety, (Synedroid), *b*, Biundulate variety = *Eu. camelus*.

(13.) *Himantidium undulatum*. Sporangial, var. *a* and *b*.

(14.) *Stauroneis legumen*, Ehr.

(15.) *Mastogloia Kinsmanii*, n. sp. *a*. V. *b*. F. V.

(16.) *Mastogloia elegans*, n. sp. F. V.

(17.) *Navicula gastrum*, Ehr.

(18.) *Eunotia bactriana*, Ehr.

(19.) *Navicula interposita*, n. sp.

(20.) *Navicula incomperta*, n. sp.

(15.) *Navicula carassius*, Ehr.

These figures are all magnified 500 diameters. The representations of *striæ* are only designed to give a general idea of their direction and character, not of number, actual or comparative.

[Jan.



